Big Innovations Start Small…

The National Reconnaissance Office CubeSat Program embodies a creative approach for launching and operating smaller satellites at a lower cost and in a quicker time frame than traditional NRO programs. Future development efforts will determine the true scope and utility of these nano-satellites; but for now the NRO has affirmed their place in maturing key technologies to enhance the nation's overhead architecture.

CubeSats are relatively low cost and flexible. Most importantly, they can utilize existing NRO launches as their gateway into orbit, a method known as rideshare. They enable the NRO, DoD, IC, and other users to explore novel architectures, field rapid, low-cost pathfinders to address complex problems, and provide a platform for rapid technology maturation.

"We have long recognized that there are benefits and efficiencies to be gained through the rideshare in space launch. These benefits include opportunities to conduct scientific research and demonstrate and apply emerging technologies through the use of small satellites," said Ms. Betty Sapp, Director, National Reconnaissance Office.

On September 13, 2012, the NRO CubeSat program launched 11 CubeSats (seven NRO-sponsored and four NASA-sponsored) as secondary payloads on NROL-36. As of January 24, 2013, eight of the 11 CubeSats have completed system checkout and are approaching an initial operating capability. Several of these CubeSats have demonstrated remarkable functionality for such small satellites.

More than 48 CubeSats are vying for launch seats in fiscal year 2013, with many more in the years to come. Within the U.S. CubeSat program, secondary payloads have been integrated and launched from various launch platforms, including Minotaur I, Minotaur IV, Falcon 1, Falcon 9, Delta II, Taurus, Atlas-V, Space Shuttle, and the International Space Station. The space community is developing low-cost, dedicated launch capabilities to further leverage the utility of CubeSats by placing them in orbit when and where they are needed.

"CubeSats have brought imagination back to the space business by allowing participation of non-traditional players," said Mr. Dave Williamson, CubeSat Program Office Technical Lead. "Many smaller corporations and universities are creatively applying concepts or tailoring parts to fit our established launch requirement."

Since the build-to-operations cycle is less than three years, allowing a university student to be involved in a CubeSat development from inception to mission, CubeSats provide vital training for the next generation of space experts. This rapid development cycle provides a junior engineer the equivalent of 10 years' of experience, allowing industry and Government to hire junior engineers with significant hands-on operational expertise in satellite engineering and development.

To learn more about the CubeSat program, we sat down with MAJ Seth Bowden and Mr. David Williamson, leaders on the innovative team responsible for NRO CubeSat research and advancement.

Questions & Answers

What is a CubeSat?

A CubeSat is a small satellite designed to fit inside a standard launch payload bus, specifically 10 cm wide by 10 cm high by 10 cm deep with a total mass of 1.33 kg. This 10x10x10 cm cube is often referred to as a 1U CubeSat. To increase overall CubeSat performance, developers created 2U, 3U, and 6U CubeSats. 2U and 3U CubeSats maintain a 10 cm width and depth but add to the height (e.g., 2U is nominally 10x10x20 cm). 6U CubeSats are essentially the marriage of two 3U CubeSats and measure 10x20x30 cm (nominally). The added volume provides space for larger payloads, increased power, better reaction wheels, more capable subsystems, and even propulsion systems.

"The CubeSat can be viewed as the Model T of satellites," said MAJ Seth Bowden, "just as standardization and simplicity made the Model T more affordable, CubeSats dramatically reduce the cost of satellites and provide increased access to space for a broad range of payload developers."

The CubeSat fills a niche in space that larger systems, with their higher costs and longer development cycles, are not designed to fill. CubeSats cannot and will not replace the NRO's traditional satellite systems, just as the Model T could not compete with the custom-built cars of its time in performance or amenities.

What is the history behind Cubesats?

The original CubeSat design was developed at California Polytechnic State University (Cal Poly) and Stanford University in 1999. The driving force behind the CubeSat standard was to create a small, inexpensive, standardized satellite to support a wide variety of demonstration applications and accommodate a shorter development cycle aligned with the academic learning cycle.

Since its inception, the CubeSat has enjoyed widespread acceptance in the space community, with a growing developer list that includes more than 70 U.S. companies, 50 U.S. universities, and 41 foreign universities.

The NRO, Air Force, and NASA have made significant investment into CubeSat activities. Extensive Government investment began in 2007 when the NRO's Advanced Systems and Technology (AS&T) Directorate and NASA assessed that CubeSats were mature enough to provide utility for government applications. AS&T established a CubeSat Program Office which actively engaged government partners, universities, service academies, laboratories, and industry, to advance the state of practice. In 2008 NRO AS&T formulated the "Innovative Experiments Initiative (IEI)," which provided funding to advance CubeSat subsystem technologies and payloads.

In 2011, the CubeSat Program Office transitioned to the NRO Mission Integration Directorate (MID), maintaining its legacy commitments while exploring applications to enable solutions to real-world problems. It is currently aligned under MID's Acquisition and Engineering Office (AEO).

What does a CubeSat do? What is it doing that was not possible before and why does that matter? What makes it innovative?

Like any satellite bus, the CubeSat provides a platform for a payload to operate in space. The CubeSat bus is special and innovative because it provides standardized interfaces with the payload and launch

mechanism. Payload engineers design their payloads to fit within the standard bus, which allows flexibility, reduces cost, and, most importantly, decreases the time from design to orbital operation to 18 months (average). This greatly decreased development cycle encourages new and innovative payloads which would not be economically or technologically feasible on a larger traditional satellite.

The standard bus architecture enables even small universities and colleges to purchase and develop their own CubeSat. Additionally, the short development cycle of a typical CubeSat mission means that the same group of students can see the CubeSat from design to integration to launch to on-orbit operations. As compared to larger systems, which anticipate a five-to-ten-year development effort, CubeSats offer a unique microcosm of the satellite design and operations cycle, and are thus an extremely effective teaching tool to use in the development of the next generation of satellite designers and operators.

What are the advantages of CubeSats and rideshare?

One key to CubeSat success and acceptance is that CubeSats reach space as a rideshare, which means CubeSats are secondary payloads on larger missions. CubeSats are deployed after the primary payload of a given mission has been deployed into its desired orbit. This rideshare concept makes launch affordable. A second key was the development of an inexpensive deployment system. Cal Poly and Stanford developed the Poly-Picosatellite Orbital Deployer (P-POD), a metal breadbox sized container that can deploy 1U, 2U and 3U CubeSats using an internal deployment spring. Once the primary payload has been deployed, the front door of the P-POD swings open and the P-POD deployment spring pushes the CubeSat into space like a jack-in-the-box.

The most obvious advantage to a rideshare approach is that the number of CubeSat orbital slots are vastly increased at a fraction of the cost of a dedicated launch. Additionally, since each rideshare slot represents a relatively low level of investment of resources and funds, the missions can be higher risk, higher reward technology demonstration efforts. The inherent low cost and aggressive timelines involved in a rideshare launch enable the CubeSat Program Office to accept missions that embody cutting edge technology development and demonstration.

Who else has the NRO worked with developing CubeSat technology and utility?

The NRO CubeSat Program Office works with various U.S. Government, academic, and industry partners in the CubeSat effort.

<u>Government Agencies</u>
Naval Postgraduate School
Naval Research Laboratory
Army Space and Missile Defense Command (SMDC)
Air Force Space and Missile Center's Space Test Program (SMC/STP)
Operationally Responsive Space (ORS) Office
Defense Advanced Research Projects Agency (DARPA)
Space and Naval Warfare Systems Command (SPAWAR)
NASA Ames
NASA Kennedy Space Center
Air Force Research Laboratory (AFRL)
NRO's Survivability Assurance Office (SAO)

U.S. Special Operations Command (USSOCOM)
Department of Homeland Security (DHS)
Defense Intelligence Agency (DIA)
Central Intelligence Agency (CIA)
National Security Agency (NSA)

Academic Partners
Johns Hopkins Applied Physics Laboratory
Utah State University Space Dynamics Laboratory (USU-SDL)
University of Southern California Information Sciences Institute (USC-ISI)
Air Force Institute of Technology (AFIT)
University of Hawai'I, Oahu

Commercial Partners
SRI International
Boeing
In-Q-Tel
Digital Solid State Propulsion
Aerospace Corporation
Pumpkin Inc.

Finally, no NRO-sponsored CubeSat would make it to orbit without the partnership with NRO's Office of Space Launch (OSL) to secure launch slots for our missions. Without their continued advocacy the program office would not be able to operate as the office of primary responsibility for NRO CubeSat activities.

Who are the users?

Broadly speaking, besides the NRO, CubeSat users include academic and Government entities such as DoD and the military services, specifically Army SMDC and USAF Joint Space Operations Center (JSpOC), and the Intelligence Community (IC), specifically NSA and CIA. The NRO is a primary user because CubeSats mature key technologies in support of the national overhead architecture.

Does the CubeSat program have ground sites?

Since 2007, the CubeSat Program Office has fielded four ground stations at sites around the United States. (NPS at Monterey, CA; Air Force Institute of Technology (AFIT) at Dayton, OH; University of Hawaii, Oahu; and USU-SDL at Logan, UT). Five more sites are planned for rollout in the coming years in coordination with NRL and NPS.